#4

PATENT
1817-0120P

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicant:	Sean Timoney et al.	Conf.:	1531
Appl. No.:	10/071,083	Group:	3617
Filed:	February 11, 2002	Examiner:	UNKNOWN

For: HYDRO-PNEUMATIC SUSPENSION SYSTEM

L E T T E R

Assistant Commissioner for Patents
Washington, DC 20231

April 10, 2002

Sir:

Under the provisions of 35 U.S.C. § 119 and 37 C.F.R. § 1.55(a), the applicants hereby claim the right of priority based on the following applications:

Country	Application No.	Filed
IRELAND	S2001/0125	February 9, 2001

A certified copy of the above-noted application are attached hereto.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fee required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By _____
James M. Slattery, #28,380
for #43,368
P.O. Box 747
Falls Church, VA 22040-0747
(703) 205-8000

JMS/glh
1817-0120P

Attachment

(Rev. 10/31/01)

Group 3617
S.N. 10/071,083
Buck Stewart et al.
(703) 205-8000
att docket 1817-D120P

Patents Office
Government Buildings
Hebron Road
Kilkenny

I HEREBY CERTIFY that annexed hereto is a true copy of documents filed in connection with the following patent application:

Application No.	S2001/0125
Date of Filing	9 February 2001
Applicant	TECHNOLOGY INVESTMENTS LIMITED, an Irish Company of Gibbstown, Navan, County Meath, Ireland.

Dated this 23 day of January 2002.

An officer authorised by the
Controller of Patents, Designs and Trademarks.

S010125

FORM NO. 1

REQUEST FOR THE GRANT OF A PATENT

PATENTS ACT 1992

The Applicant(s) named herein hereby request(s)
[ ] the grant of a patent under Part II of the Act
[X] the grant of a short-term patent under Part III of the Act
on the basis of the information furnished hereunder.

1. Applicant(s)

TECHNOLOGY INVESTMENTS LIMITED.
Gibbstown
Navan
County Meath
Ireland
an Irish Company

2. Title of Invention
Hydro-pneumatic suspension system

3. Declaration of Priority on basis of previously filed application(s) for same invention (Sections 25 & 26)

Previous Filing Date	Country in or for which filed	Filing No.

4. Identification of Inventor(s)

Name(s) and addresse(s) of person(s) believed by the Applicant(s) to be the inventor(s)
Colin James Anderson
a British Subject of Lackmelch, Balrath Road, Kells, County Meath, Ireland
Sean Timoney
an Irish Citizen of 5 St Marys Road, Dublin 4, Ireland

5. Statement of right to be granted a patent (Section 17(2) (b))

The Applicant derives the right to apply by virtue of a Deed of Assignment dated December 21, 2000

6. Items accompanying this Request

(i)	[X]	prescribed filing fee (IRP 50)
(ii)	[ ]	specification containing a description and claims
	[X]	specification containing a description only
	[X]	Drawings referred to in description or claims
(iii)	[ ]	An abstract
(iv)	[ ]	Copy of previous application(s) whose priority is claimed
(v)	[ ]	Translation of previous application whose priority is claimed
(vi)	[X]	Authorisation of Agent (this may be given at 8 below if this Request is signed by the Applicant(s))

7. Divisional Application(s)
The following information is applicable to the present application which is made under Section 24 -

Earlier Application No.
Filing Date:

8. Agent

The following is authorised to act as agent in all proceedings connected with the obtaining of a patent to which this request relates and in relation to any patent granted -

Name & Address

Cruickshank & Co. at their address recorded for the time being in the Register of Patent Agents is hereby appointed Agents and address for service, presently 1 Holles Street, Dublin 2.

9. Address for service (if different from that at 8)

Signed Cruickshank & Co.

By:- Executive.

Agents for the Applicant

Date February 09, 2001.

APPLICATION No. S010125

"Hydro-Pneumatic Suspension System"

Introduction

This invention relates to hydro-pneumatic springs and in particular to hydro-pneumatic springs used in vehicle suspension systems.

A hydro-pneumatic spring uses hydraulic fluid to transmit force to a variable volume gas chamber which acts as a spring. Hydro-pneumatic suspension systems for vehicles offer a number of advantages which include a rise in spring rate as the spring is compressed into bump and the possibility of adding additional features such as integral damping, variable damping, variable ride height, and load compensation. The non-linear spring characteristic, while advantageous as the spring is compressed towards the full bump position, creates a problem as the spring is extended towards the full rebound position because at full rebound, there is usually a large residual force remaining in the spring. This has an adverse effect on vehicle roll when cornering.

The present invention is directed towards overcoming this problem.

Statements of Invention

According to the invention, there is provided a suspension system for a vehicle incorporating a hydro-pneumatic spring and an associated compensating spring means which acts in opposition to the force exerted by the hydro-pneumatic spring as said hydro-pneumatic spring approaches full extension.

In a preferred embodiment, the compensating spring comprises an elastic element of solid material such as metal or rubber. The compensating spring may conveniently be provided by a coil spring.

In another embodiment, the hydro-pneumatic spring has an oil chamber and an associated gas chamber with a separator piston or membrane therebetween, the spring means acting to reduce the force exerted by the separator piston or membrane on the oil in the oil chamber.

In a preferred embodiment, the compensating spring is a coil spring located within the hydro-pneumatic spring.

In a further embodiment, the compensating spring is mounted externally of the hydro-pneumatic spring and is operable to reduce the force exerted by the hydro-pneumatic spring as said hydro-pneumatic spring approaches full extension.

In another embodiment, the compensating spring is in series with a check strap that limits the extension of the hydro-pneumatic spring.

In another embodiment, the suspension system includes an upper control arm and an associated lower control arm, which locate a wheel with respect to a vehicle body, the hydro-pneumatic spring providing the suspension force tending to extend the suspended wheel away from the vehicle body and one or more compensating springs act between the vehicle body and one or both of the upper and lower control arms to reduce the suspension force as the hydro-pneumatic spring approaches full extension.

In a further embodiment, the compensating spring is a torsion bar.

In another embodiment, the compensating spring is a hydro-pneumatic spring element.

Detailed Description of the Invention

The invention will be more clearly understood by the following description of some embodiments thereof, given by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is an elevational view illustrating the general arrangement of an independent wheel suspension system incorporating a hydro-pneumatic spring according to the invention,

Fig. 2 is a sectional elevational view of a hydro-pneumatic spring of the system which incorporates a compensating spring in the form of an internal coil spring,

Fig. 3 is a view similar to Fig. 1 showing the general arrangement of an independent wheel suspension system incorporating a hydro-pneumatic spring and a compensating spring according to a second embodiment of the invention, the compensating spring being mounted externally of the hydro-pneumatic spring and in series with a check strap which limits the extension of the hydro-pneumatic spring,

Fig. 4 is a schematic illustration showing an arrangement in which a suspension actuator is separate from the hydro-pneumatic spring element and the compensating spring is internal to the hydro-pneumatic spring element and acts to reduce the force exerted by the gas on the oil as the gas volume increases towards its maximum value,

Fig. 5 is a schematic illustration showing an arrangement in which the suspension actuator is separate from the hydro-pneumatic spring element and the compensating spring is internal to the suspension actuator and acts to reduce the force exerted by the suspension actuator as it approaches full extension,

Fig. 6 is a schematic illustration showing an arrangement in which the suspension actuator is a double-acting hydraulic ram separate from the hydro-pneumatic spring element and the compensating spring is a second hydro-pneumatic spring element connected to the rod end of the suspension actuator and acts to reduce the force exerted by the suspension actuator as it approaches full extension, and

Fig. 7 is a graph illustrating strut characteristics of a hydro-pneumatic spring of the invention.

Referring to the drawings, and initially to Fig. 1 thereof, there is illustrated one side of an independent wheel suspension system according to the invention, indicated generally by the reference numeral 1, the other side of the system, which is located at an opposite side of the vehicle, being similar. The suspension system 1 incorporates a

hydrostrut, hydraulic suspension actuator or hydro-pneumatic spring 2. In this case, the suspension system incorporates an upper control arm 3 and a lower control arm 4 to locate a wheel carrier 5 with respect to a vehicle body 6. The hydro-pneumatic spring 2 is connected at its upper end to the vehicle body 6 by an articulated joint 8 and at its lower end 7 to the lower control arm 4. It will be understood that this type of suspension system is shown for the purpose of illustration only and that the invention may be used in conjunction with many different types of suspension system. The hydro-pneumatic spring 2 is under compression and provides the suspension force tending to extend the suspended wheel downwardly away from the vehicle body.

Referring to Fig. 2, there is shown a sectional view of a hydro-pneumatic spring 2 according to the invention. The hydro-pneumatic spring 2 comprises an inner cylinder 9, an inner end of which is slidable within an outer cylinder 10. The inner cylinder 9 contains a variable volume of gas 11 above a separator piston 12. The remaining volume 13 of inner cylinder 9 is filled with oil and communicates with an oil-filled outer cylinder volume 14 through a damper orifice 15. It will be noted that in this embodiment of the invention, a compensating spring 16 is located internally of the inner cylinder 9. As the hydro-pneumatic spring 2 extends into rebound, the separator piston 12 comes into contact with the compensating spring 16 and begins to compress it. This has the effect of reducing the force exerted by the separator piston 12 on the oil in the hydro-pneumatic spring 2. The compensating spring 16 free length and stiffness may be chosen to give a hydro-pneumatic spring force which decreases gradually from a suitable load level such as the static load value to zero at full rebound, as shown in Fig. 7.

Referring now to Fig. 3, there is shown another suspension system which is largely similar to the suspension system shown in Fig. 1 and like parts are assigned the same reference numerals. In this case, a check strap 17 is provided which serves to limit the extension of the hydro-pneumatic spring 2. The check strap 17 is located between the vehicle body 6 and the lower control arm 4. It will be noted that the compensating spring 16 is in this case located externally of the hydro-pneumatic spring 2 and in series with the check strap 17. As the hydro-pneumatic spring 2 extends into rebound, the check strap 17 becomes taut and starts to compress the compensating spring 16. The force in the compensating spring 16 counteracts the residual force in the hydro-

pneumatic spring 2. The compensating spring 16 free length and stiffness may be chosen to give a resultant spring force which decreases gradually from a suitable load level such as the static load valve to zero at full rebound as shown in Fig. 7.

Referring now to Fig. 4, there is shown schematically another construction of suspension system in which parts similar to those described previously are assigned the same reference numerals. In this case, a suspension actuator or strut 18, which is mounted between the body at 8 and the lower control arm 4 at 7, is separate from the hydro-pneumatic spring element 19. The strut 18 has a piston 20 slidable within an associated cylinder 22. The hydro-pneumatic spring 19 is separated into a gas volume 11 and an oil volume 13 by a separator membrane or piston 12. The oil volume 13 communicates with the oil volume 14 in the suspension actuator or strut 18 through damping orifice 15. The compensating spring 16 is internal to the hydro-pneumatic spring element 19 and acts to reduce the force exerted by the gas on the oil as the gas volume increases towards its maximum value in precisely the same manner as in the embodiment illustrated in Fig. 2.

Referring to Fig. 5, there is shown schematically another embodiment which is largely similar to that of Fig. 4 and like parts are assigned the same reference numerals. However, in this case, the compensating spring 16 is located in the suspension strut 18. The strut piston 20 comes into contact with the compensating spring 16 as the suspension moves into rebound and the force in the compensating spring 16 counteracts the residual force in the suspension strut 18.

Referring now to Fig. 6, there is shown schematically another suspension system in which parts similar to those described previously are assigned the same reference numerals. In this case, the suspension strut 18 is a double acting hydraulic ram separate from the hydro-pneumatic spring element 19 and the compensating spring 16 is a second hydro-pneumatic spring element connected to a rod end volume 21 of the suspension strut 18 and acts to reduce the force exerted by the suspension strut 18 as it approaches full extension.

It will be appreciated that the hydro-pneumatic spring 2 or strut 18, when used in an independent suspension system of the type shown in Figs. 1 and 3, may be mounted

between the vehicle body 6 and either the upper control arm 3 or lower control arm 4.

The invention is not limited to the embodiments hereinbefore described which may be varied in both construction and detail.

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prelim3\ps0042

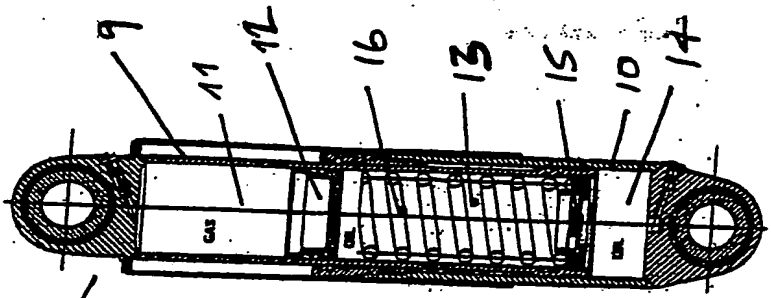


FIG2

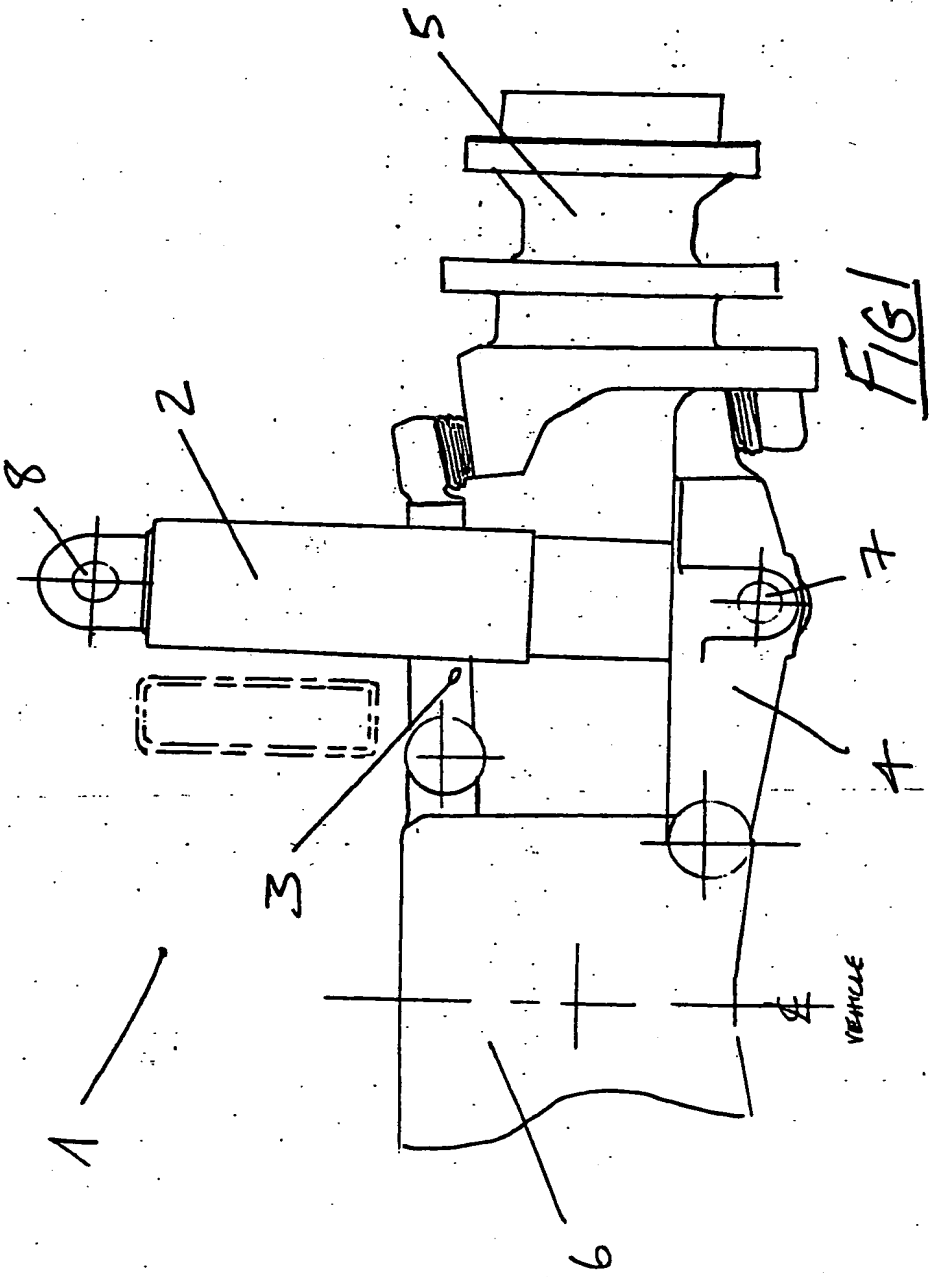


FIG1

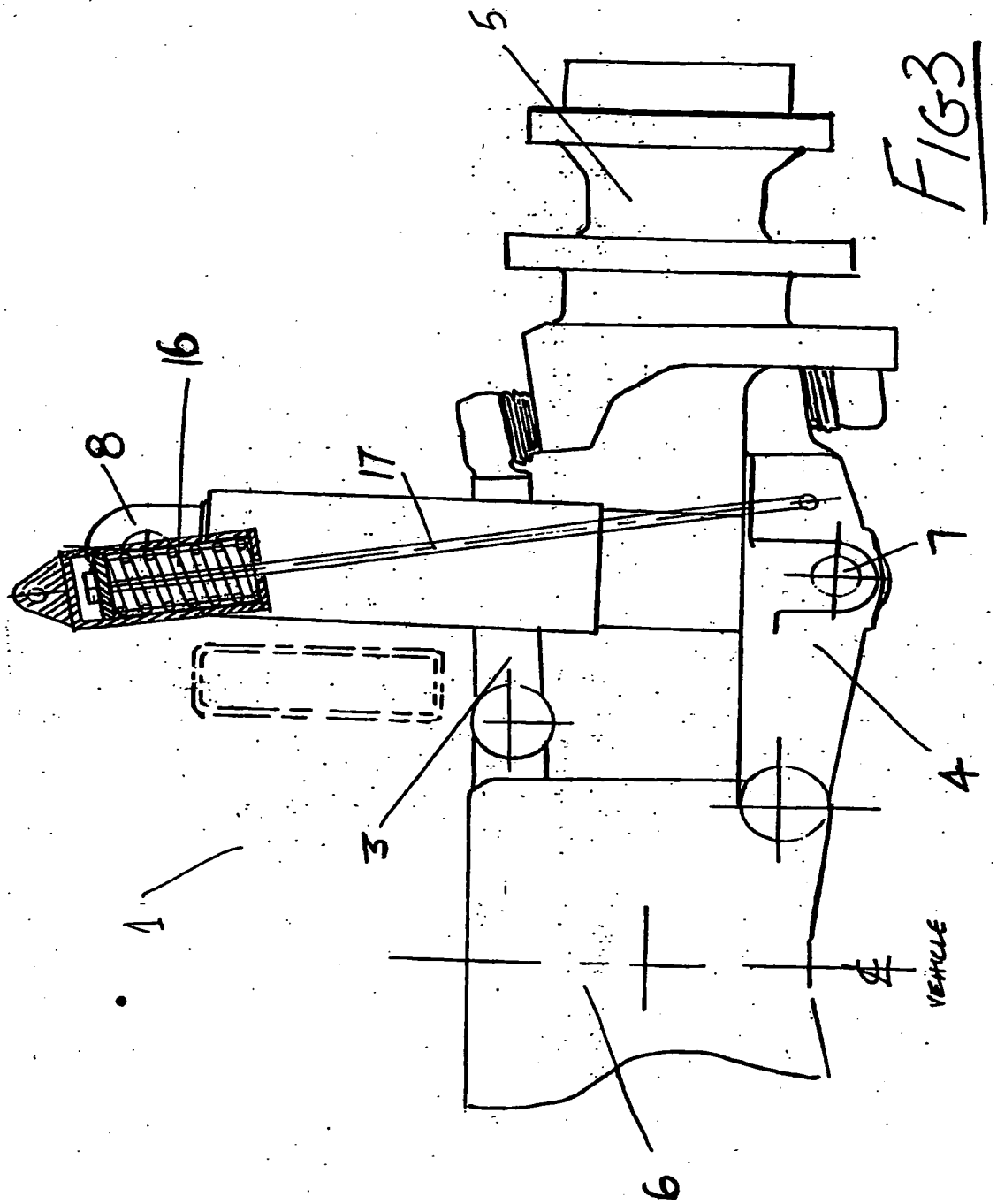


FIG3

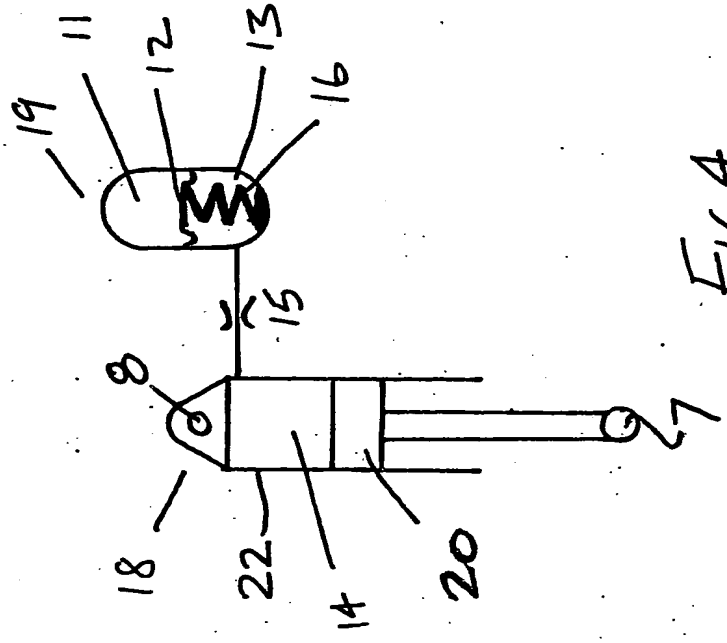


FIG 4

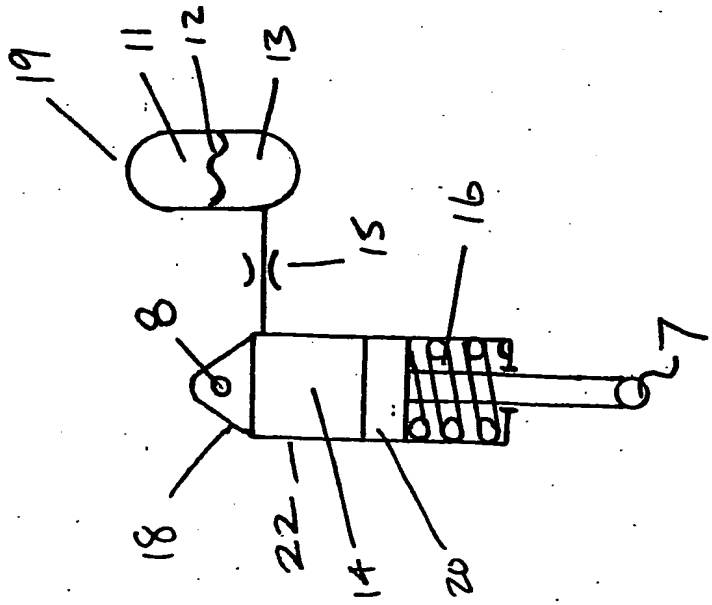
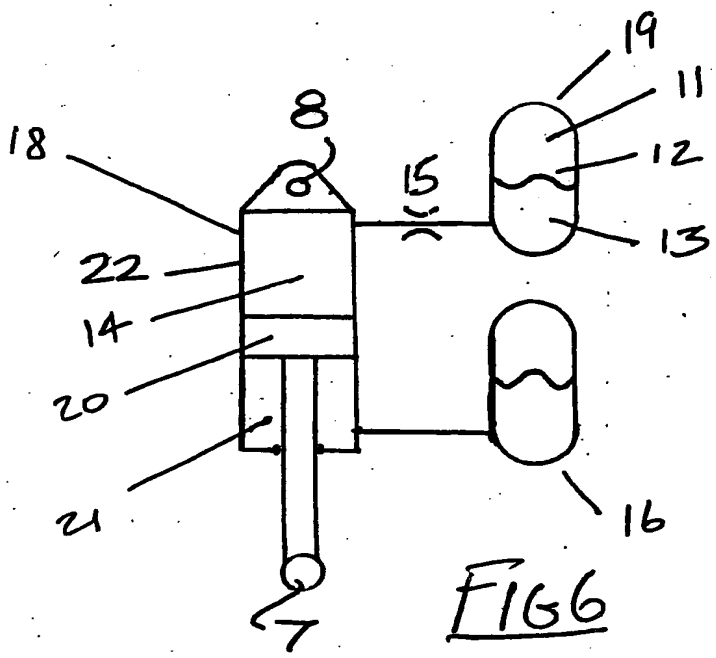


FIG 5


19
11
8
18
12
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13
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16
7

FIG6

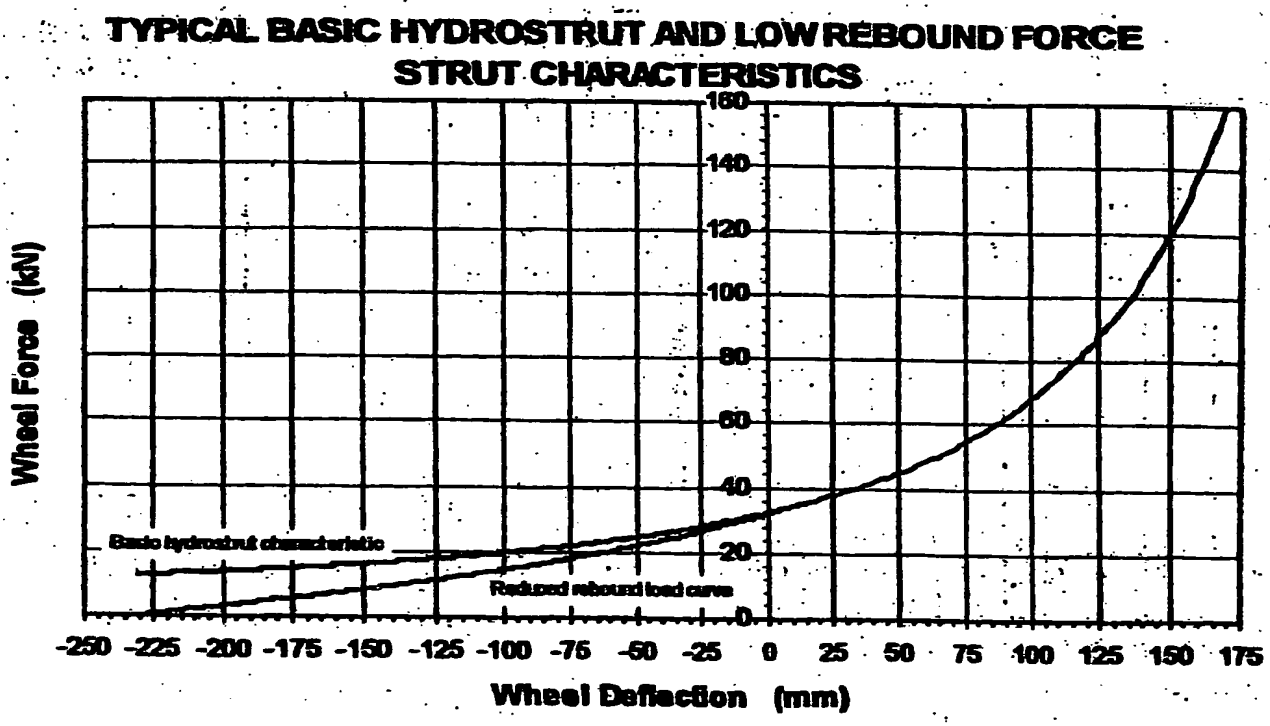
TYPICAL BASIC HYDROSTRUT AND LOW REBOUND FORCE STRUT CHARACTERISTICS
Wheel Force (kN)
160
140
120
100
80
60
40
20
0
Basic hydrostrut characteristic
Reduced rebound load curve
-250 -225 -200 -175 -150 -125 -100 -75 -50 -25 0 25 50 75 100 125 150 175
Wheel Deflection (mm)

FIG7